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VARIATIONS IN JUVENILE OAK

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Abstract.—Data from research on 13-year-old trees in an oak planting in southeastern Pennsylvania indicate that survival and growth are not correlated with source latitude within all species tested. A complete listing of species and seed origins, along with performance of progenies, is presented for persons interested in oak improvement.

The Michaux Quercetum study is a joint project of the Morris Arboretum of the University of Pennsylvania and the Northeastern Forest Experiment Station of the USDA Forest Service, financed in part by the Michaux Fund of the American Philosophical Society. One of the objectives of the study is to provide information about the variation within oak (*Quercus*) species.

Methods

Seed from individual wild trees was supplied by cooperators. Each collection was accompanied by herbarium specimens; suspected natural hybrids were excluded from the study. Seeds were sown in the fall of 1953, and seedlings were outplanted at seven locations in 1957.

In previous reports, Gabriel (*1958*), Li (*1955*), Santamour (*1960*), Santamour and Schreiner (*1961*), Schramm and Schreiner (*1954*), and Schreiner and Santamour (*1961*) have presented details about the earlier stages of this study and have described juvenile variation in a number of species.

The planting at Longwood Gardens, Kennett Square, Pennsylvania, (lat. 40°50′ W.) was remeasured in October 1966, 10 years after outplanting and 13 years after seeding. This planting includes progeny from 78 trees representing 13 species. The height and diameter of each surviving tree were measured, and its form was rated (table 1).

Differences in mean height and diameter

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Table 1.—Growth form, and survival of oak provenances at Longwood Gardens, Pa., 10 years after outplanting

Number	Species	Source	Number planted	Mean height	Mean diameter	Average form[a]	Survival
				Feet	*Inches*		*Percent*
017	*Q. rubra*	N.H.	31	15.0	1.2	2.4	25.8
018	*Q. rubra*	N.H.	30	19.2	2.7	2.0	46.7
019	*Q. rubra*	N.H.	31	18.0	2.2	2.1	51.6
020	*Q. rubra*	N.H.	32	14.5	1.3	2.2	40.6
376	*Q. rubra*	Penna.	32	15.8	2.1	2.3	15.6
377	*Q. rubra*	Penna.	29	15.7	2.0	2.4	41.4
416	*Q. rubra*	Ill.	30	14.9	1.8	2.6	70.0
418	*Q. rubra*	Ill.	34	17.6	2.0	2.2	67.6
426	*Q. rubra*	Ill.	32	17.4	2.2	1.8	81.2
471	*Q. rubra*	Ill.	32	16.8	2.1	2.2	53.1
052	*Q. rubra*	Kan.	32	15.2	2.2	2.6	53.1
058	*Q. rubra*	Kan.	30	14.5	1.6	2.7	50.0
209	*Q. rubra*	N.C.	30	15.1	1.8	2.3	26.7
210	*Q. rubra*	N.C.	30	15.8	1.7	2.1	30.0
212	*Q. rubra*	N.C.	30	14.7	1.6	2.3	43.3
379	*Q. velutina*	Ill.	29	16.8	2.1	2.1	62.1
422	*Q. velutina*	Ill.	30	15.8	1.8	2.2	36.7
425	*Q. velutina*	Ill.	30	14.0	1.7	2.5	40.0
428	*Q. velutina*	Ill.	27	16.2	1.9	2.2	77.8
372	*Q. velutina*	N.C.	28	15.9	2.2	2.1	71.4
233	*Q. velutina*	Tenn.	32	15.1	2.0	2.1	25.0
234	*Q. velutina*	Tenn.	30	15.3	1.9	2.0	50.0
290	*Q. velutina*	Ala.	28	17.8	1.8	1.9	28.6
291	*Q. velutina*	Ala.	26	15.4	1.7	2.0	46.2
107	*Q. velutina*	Va.	32	14.1	1.6	2.4	40.6
366	*Q. velutina*	Mich.	28	15.7	1.9	1.9	71.4
550	*Q. coccinea*	Ill.	19	12.3	1.1	2.3	21.1
470	*Q. coccinea*	Ill.	32	15.7	1.8	1.8	37.5
231	*Q.coccinea*	Tenn.	31	13.3	1.5	2.4	25.8
232	*Q. coccinea*	Tenn.	30	15.4	1.8	2.1	63.3
289	*Q. coccinea*	Ala.	30	14.5	1.7	2.4	60.0
293	*Q. coccinea*	Ala.	30	14.9	1.8	2.2	60.0
108	*Q. coccinea*	Va.	30	16.1	2.0	2.3	66.7
420	*Q. shumardii*	Ill.	20	17.9	2.5	2.2	85.0
215	*Q. shumardii*	Tenn.	20	17.5	2.4	2.0	60.0
284	*Q. shumardii*	Miss.	20	19.4	2.6	1.9	65.0
332	*Q. shumardii*	Fla.	20	15.4	1.7	2.5	55.0
214	*Q. shumardii*	Tenn.	20	16.3	2.4	2.6	65.0
287	*Q. shumardii*	Miss.	20	11.7	1.3	2.8	65.0
354	*Q. macrocarpa*	Minn.	18	9.3	0.7	2.3	16.7
355	*Q. macrocarpa*	Minn.	17	10.7	0.9	2.0	17.6
185	*Q. macrocarpa*	S.D.	30	12.9	1.5	2.8	33.3
186	*Q. macrocarpa*	S.D.	42	12.5	1.5	2.8	52.4
053	*Q. macrocarpa*	Kan.	13	16.8	3.2	2.7	84.6
402	*Q. macrocarpa*	Kan.	30	16.2	2.6	2.4	56.7
582	*Q. falcata*	Md.	6	13.0	1.5	2.5	33.3
409	*Q. falcata*	Va.	16	13.0	1.6	2.7	37.5
410	*Q. falcata*	Va.	20	14.0	1.9	2.4	50.0
412	*Q. falcata*	Va.	17	16.9	2.3	2.2	29.4
292	*Q. falcata*	Ala.	8	14.0	1.6	1.7	37.5
298	*Q. falcata*	Ark.	10	16.2	2.4	1.8	50.0
462	*Q. imbricaria*	Ind.	18	14.1	1.7	2.4	61.1
350	*Q. imbricaria*	Ohio	19	14.9	1.9	2.3	73.7
351	*Q. imbricaria*	Ohio	20	14.7	2.1	2.5	70.0
417	*Q. imbricaria*	Ill.	20	16.4	2.2	2.4	70.0
031	*Q. nigra*	Md.	20	13.8	1.8	3.0	42.1
033	*Q. nigra*	Md.	14	17.5	1.8	3.0	14.3
408	*Q. nigra*	Va.	17	14.5	1.8	2.5	76.5
414	*Q. nigra*	Va.	18	13.4	1.6	2.8	83.3
286	*Q. nigra*	Miss.	16	13.3	1.5	2.9	75.0
299	*Q. nigra*	Ark.	20	15.0	2.1	2.6	75.0

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Table 1.—Continued

Number	Species	Source	Number planted	Mean height	Mean diameter	Average form[a]	Survival
				Feet	*Inches*		*Percent*
576	*Q. phellos*	Md.	10	14.0	2.5	2.0	10.0
584	*Q. phellos*	Md.	20	15.3	2.2	2.2	45.0
411	*Q. phellos*	Va.	20	13.1	1.9	2.5	30.0
413	*Q. phellos*	Va.	20	16.2	2.3	1.8	40.0
285	*Q. phellos*	Miss.	20	12.6	2.0	2.6	25.0
297	*Q. phellos*	Ark.	20	14.2	1.9	2.4	65.0
227	*Q. marilandica*	N.J.	8	9.5	0.6	3.0	25.0
057	*Q. marilandica*	Kan.	16	10.3	1.3	2.7	37.5
299	*Q. marilandica*	Ark.	20	8.7	1.0	3.0	30.0
016	*Q. marilandica*	Texas	20	9.0	0.9	3.0	15.0
349	*Q. palustris*	Ohio	14	18.4	2.6	1.7	50.0
424	*Q. palustris*	Ill.	14	17.7	2.8	1.6	50.0
348	*Q. palustris*	Ohio	8	18.5	3.6	1.5	25.0
474	*Q. stellata*	Mo.	8	13.5	1.0	2.0	12.5
581	*Q. stellata*	Md.	8	12.0	1.1	2.5	25.0
601	*Q. variabilis*	Va.[b]	5	15.3	3.1	3.0	60.0
602	*Q. variabilis*	Va.[b]	15	14.7	2.1	3.0	40.0

[a] Form rating: 1—single stem, no sweep or crooks. 2—stem bifurcates above 8 feet, may have slight sweep or crook. 3—stem bifurcates below 8 feet; sweep or crook that may make tree worthless for timber use.

[b] Native to Asia. Seed for this study was collected from trees planted in Virginia.

Table 2.—Height differences within species and correlations of height, diameter, and survival with latitude of seed source 10 years after field planting

Species	Sources	Height	Correlation Height/lat.	Correlation Diameter/lat.	Correlation Survival/lat.
	No.	*Feet*			
Q. rubra	15	3.796**	+0.389	+0.044	—0.096
Q. velutina	11	1.305	— .175	+ .102	+ .363
Q. coccinea	7	0.840	+ .027	— .149	— .461
Q. shumardii	6	12.140**	— .062	+ .610	+ .738
Q. falcata	6	0.794	— .386	— .372	— .448
Q. macrocarpa	6	8.960**	—	—	—[a]
Q. phellos	6	1.280	—	—	—
Q. nigra	6	1.030	—	—	—
Q. imbricaria	4	0.101	—	—	—

** Significant at 0.01 level of probability. All others are not significant.

[a] Latitude of seed source no longer available.

were analyzed by ANOVA; and correlation coefficients of height, diameter, and survival over latitude of seed source were obtained for most species (table 2).

Results

Though the data were limited, we felt that the fairly wide range of the sample for some species would provide some estimates of adaptibility (survival in southeastern Pennsylvania). For those species represented by several seed sources from different latitudes, the correlation between latitude and survival was calculated. None of the correlations was statistically significant.

Red oak (*Quercus rubra* L.) was represented by 15 seed sources. Seedlots were significantly different in height after 13 growing seasons. The two tallest sources were both from Hillsboro County, New Hampshire, and had heights that were 123 percent and 115 percent of the grand mean for all *Q. rubra* seedlots. The other two seed lots from

the same county had heights that were 93 percent and 88 percent of the mean, the latter being very close to the shortest source.

Black oak (*Quercus velutina* Lamb.) was represented by 11 sources. Differences in mean height were not significant.

Scarlet oak (*Quercus coccinea* Muenchh.) height differences were not significantly different. The range in latitude was small, and this may explain the low correlation between growth and latitude if latitude is an important factor.

Shumard oak (*Quercus shumardii* var shumardii) was represented by sources from Florida to Illinois, and highly significant differences were observed in mean heights. Tree-to-tree variation as contrasted with source location was clearly evident. Sources having the highest and lowest mean heights were from the same county in Mississippi. This means that the variation in growth of progeny from trees from the same area exceeded the variation between trees from other areas.

Burr oak (*Quercus macrocarpa* Michx.) sources were from three states, and highly significant differences were observed in mean heights. The most southerly sources (Kansas) produced the tallest trees; but because the exact locations within Kansas were not available, the correlation between latitude and height growth or survival could not be computed.

Southern red oak (*Quercus falcata* var. falcata Michx.) height differences were not significantly different, and survival was not correlated with latitude of seed source.

Water oak (*Quercus nigra* L.) and willow oak (*Quercus phellos* L.) did not yield significant differences in height within species, and data on county origin were not available for comparing latitude of source with survival.

A few sources of shingle oak (*Quercus imbricaria* Michx.), blackjack oak (*Quercus marilandica* Muenchh.), pin oak (*Quercus palustris* Muenchh.), post oak (*Quercus stellata* Wangenh.), and a species (*Quercus variabilis* Bl.) introduced from Asia with foliage similar to chestnut (*Castanea*) were included in the planting. Remeasurement data are included in table 1. No attempt was made to compare sources within these species.

In Conclusion

The number of trees used, the method of selection, and the design used in the planting at Longwood Gardens do not constitute a valid seed-source test. Even the 15 sources of red oak or the 11 sources of black oak do not adequately sample the botanical ranges.

Our conclusion is that height growth is not correlated with seed-source latitude for the species of oak included in this report. The tallest and shortest trees may be from the same county, which suggests that trees from the same area may contain as much variation in growth potential as trees from widely separated stands. Another finding is that survival was not correlated with latitude of seed source. There is no evidence that trees from one geographic region have a greater chance of surival than trees from any other region, and we found no visual evidence of cold-induced damage on any tree in the planting.

This authenticated collection of oak species at Longwood Gardens is available for breeding programs, particularly interspecific hybridization, with this important hardwood genus. Individual-tree information can be obtained from the genetics project of the USDA Forest Service, Northeastern Forest Experiment Station, at Durham, New Hampshire.

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